DESCRIPTION

DIGITAL DATA RECORDING/REPRODUCTION METHOD, AND DIGITAL DATA RECORDING/REPRODUCTION APPARATUS

TECHNICAL FIELD

The present invention relates to methods and apparatuses for recording and reproducing digital data in/from disk recording media and, more particularly, to a digital data recording/reproduction method for preventing the destruction of a file and the loss of data when an abend such as a power failure occurs, and a digital data recording/reproduction apparatus using the digital data recording/reproduction method.

BACKGROUND ART

As a conventional method for preventing the destruction of a file and the loss of data which occur during a power failure, Japanese Published Patent Application No. Hei.8-255001 discloses a method using an uninterruptable power supply (UPS) which can temporarily supply power during a power failure.

Hereinafter, the structure and operation of a conventional UPS system will be described with reference to

figure 16.

Figure 16 is a diagram illustrating the structure of the conventional UPS system.

The conventional UPS system comprises: an I/0 unit 1302 for inputting and outputting data; a control PC (personal computer) 1301 for receiving an output signal from the I/0 unit 1302, and for outputting a control signal to the I/0 unit 1302 for process control; a UPS 1304 for temporarily supplying power when a power failure occurs; and an operation check circuit 1303 for receiving a commercial power supply break signal from the UPS 1304, which indicates the state of power failure of a commercial power supply, for deciding that a power failure occurs when the commercial power supply break signal continues for longer than a predetermined time, and for outputting a signal to the control PC 1301 to inform the control PC 1301 that a power failure occurred.

Upon receipt of the signal from the operation check circuit 1303 informing that a power failure occurred, the control PC 1301 closes the active file. Further, the operation check circuit 1303 monitors the power supply voltage, and when something abnormal occurs, the operation check circuit 1303 automatically reports the abnormality by using a telephone-line automatic report unit 1305.

As described above, according to the conventional UPS system,

since the control PC 1301 can close the active file even when a power failure occurs, destruction of the active file or a loss of data hardly occurs during the power failure.

By the way, there are tape media typified by a VCR as recording media of digital data recording/reproduction apparatuses that are intended for home use. In recent years, instead of the tape media, random-accessible disk recording media, such as magnetic disks and optical magnetic disks, have been used.

When a power failure occurs during the recording of data on the conventional tape medium, video data up to the power failure is stored in the medium. However, in the case of a disk recording medium constituted for use in a computer, all of the video data which have been recorded from the start of recording to the power failure are lost unless the recording end process is correctly performed.

Hereinafter, with reference to figure 17, a description will be given of the reason why the destruction of a file or the loss of data occurs when a power failure occurs during data recording on a disk recording medium that are constructed for use in a computer.

Figure 17 shows a file structure in a recording area of a disk recording medium, which is employed in an operating system (OS) of a computer such as MS-windows (produced by Microsoft).

The recording area of the disk recording medium is composed of a root directory 1401, a file allocation table 1402, and clusters 1403.

The root directory 1401 holds the title of each file that is stored in the disk recording medium and the corresponding head cluster number of each of the files. The file allocation table 1402 holds connection information of the clusters 1403 by which each of the files are constituted. The clusters 1403 are the smallest units of data that are recorded on or reproduced from the disk recording medium, and the actual clusters 1403 hold actual data.

In the example of figure 17, the root directory 1401 indicates that a file titled "Data 1" is stored in this disk recording medium and that Data 1 starts from the cluster number 0002, i.e., cluster number 0002 is the head cluster number of Data 1. The file allocation table 1402 indicates that Data 1 is composed of the clusters having the cluster numbers 0002, 0003, and 0004. Accordingly, the actual data of Data 1 is stored in the areas corresponding to the clusters 1403 having the cluster numbers 0002, 0003, and 0004. In the file allocation table 1402, FFFF is the cluster number indicating the final cluster of the file.

Initially, when data is recorded, the file name and the head cluster number are entered in the root directory 1401, and the

actual data is recorded in the respective clusters 1403 while the connection information of the clusters 1403 is updated in the file allocation table 1402.

By the way, the root directory 1401 and the file allocation table 1402 are fixed in the disk recording medium, and the area of the disk recording medium other than the areas used by the root directory 1401 and the file allocation table 1402 is used as the areas of the respective clusters 1403.

At the time of data recording, when the cluster connection information and the actual data are written in the file allocation table 1402 and in each area of the cluster 1403, respectively, the cluster connection information in the file allocation table 1402 must be updated each time the data is written in the cluster 1403. So, there arises a need to seek the write head onto the disk recording medium, whereby the write speed is considerably decreased.

In order to solve this problem, there is adopted a method in which data is written in the cluster 1403 while the information of the file allocation table 1402 is updated in a memory, and the information of the file allocation table 1402 is reflected onto the disk recording medium when the data recording has ended, i.e., when the file is closed.

In the above-described data recording in the disk recording medium, however, if a power failure occurs before the recording end

process is executed, since the file allocation table 1402 in the disk recording medium is not yet updated, the cluster connection information on the file allocation table 1402 is lost although data has been recorded in the clusters 1403 from the start of recording to the power failure, thereby resulting in the destruction of a file and the loss of data.

Further, the use of the conventional UPS as a countermeasure against a loss of data increases the price of the digital data recording/reproduction apparatus for home use.

The present invention is made to solve the above-described problems. It is an object of the present invention to provide an inexpensive method and apparatus for digital data recording/reproduction which prevent destruction of a file and the loss of data when an abend, such as a power failure, occurs during data recording.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a digital data recording/reproduction method for recording and reproducing digital data in units of clusters, where each cluster is the smallest unit of data recording on a disk recording medium. This method comprises: a first step of constructing a file structure on the disk recording medium in which recordable clusters are connected before recording of the data is

begun; a second step of recording digital data from the head of the recordable clusters; and a third step of constituting, as a recorded file, the digital data from a recording head cluster to a recording end cluster.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the area where the digital data is recorded exists as a part of file when power is restored, and the data which has been recorded from the start of recording to the abend can be reproduced after recovery from the abend. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a second aspect of the present invention, the digital data recording/reproduction method of the first aspect further comprises the steps of: detecting, when an abend occurs during data recording in the second step, the abend of data recording after recovery from the abend; and constituting, as a recorded file, the digital data which has been recorded from the start of data recording to the abend on the basis of format information of the digital data.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the digital data which has been recorded from the start of recording to the abend can be reproduced when power is restored. Furthermore, the recordable area can be restored as a recorded file which is identical to a file that

is obtained when data recording is normally ended. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a third aspect of the present invention, in accordance with the digital data recording/reproduction method of the second aspect, the format information of the digital data is a sync byte of a transport packet.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the digital data which has been recorded from the start of recording to the abend can be reproduced upon restoration of power and, furthermore, the recordable area can be restored as a recorded file which is identical to a file that is obtained when data recording is normally ended. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a fourth aspect of the present invention, in accordance with the digital data recording/reproduction method of the second aspect, the format information of the digital data is time information.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the digital data which has been recorded from the start of recording to the abend can be reproduced upon restoration of power and. Furthermore, the recordable area can be restored as a recorded file which is

identical to a file that is obtained when data recording is normally ended. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a fifth aspect of the present invention, there is provided a digital data recording/reproduction method for recording and reproducing digital data in units of clusters, where each cluster is the smallest unit of data recording on a digital recording medium. This method comprises the steps of: recording digital data in the clusters with a file identifier and cluster connection information being added to the digital data; detecting, when an abend occurs during data recording, the abend of data recording after recovery from the abend; and restoring the cluster connection information on the basis of the file identifier and the cluster connection information which are recorded in the clusters.

Therefore, even if an abend occurs during recording of digital data, the file allocation table of the data file which has been recorded from the start of recording to the abend can be restored when power is restored, whereby the reproducible area can be restored in a file format. Accordingly, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a sixth aspect of the present invention, a

digital data recording/reproduction apparatus comprises: a disk recording medium in which digital data is stored in units of clusters, where each cluster is the smallest unit of data recording; and a file structure management unit for storing the digital data in the disk recording medium or for reading the digital data from the disk recording medium. The disk recording medium has a file structure in which all of clusters are connected in advance of starting data recording.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the area where the digital data is recorded exists as a part of a file when power is restored. Therefore, the data which has been recorded from the start of recording to the abend can be reproduced after recovery from the abend. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a seventh aspect of the present invention, in accordance with the digital data recording/reproduction apparatus of the sixth aspect, the file structure management unit has a file recovery unit. When an abend occurs during recording of digital data, the file recovery unit constitutes, as recorded data, the digital data which has been recorded from the start of data recording to the abend, on the basis of format information of the digital data, after recovery from the

abend.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the digital data which has been recorded from the start of recording to the abend can be reproduced upon restoration of power. Furthermore, the recordable area can be restored as a recorded file which is identical to a file that is obtained when data recording is normally ended. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to an eighth aspect of the present invention, in accordance with the digital data recording/reproduction apparatus of the seventh aspect, the format information is a sync byte of a transport packet.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the digital data which has been recorded from the start of recording to the abend can be reproduced upon restoration of power. Furthermore, the recordable area can be restored as a recorded file which is identical to a file that is obtained when data recording is normally ended. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a ninth aspect of the present invention, in accordance with the digital data recording/reproduction apparatus of the seventh aspect, the format information is time

information.

Therefore, even if an abend such as a power failure occurs during recording of digital data, the digital data which has been recorded from the start of recording to the abend can be reproduced upon restoration of power. Furthermore, the recordable area can be restored as a recorded file which is identical to a file that is obtained when data recording is normally ended. As a result, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to a tenth aspect of the present invention, a digital data recording/reproduction apparatus comprises: a disk recording medium in which digital data is stored in units of clusters, where each cluster is the smallest unit of data recording; and a file structure management unit for storing digital data in the clusters of the disk recording medium with a file identifier and cluster connection information being added to the clusters, or for reading the digital data from the disk recording medium. The file structure management unit has a file recovery unit. When an abend occurs during recording of digital data, the file recovery unit constitutes, as recorded data, the digital data which has been recorded from the start of data recording to the abend, on the basis of the file identifier and the cluster connection information which are recorded in the clusters, after recovery from the abend.

Therefore, even if an abend occurs during recording of digital data, the file allocation table of the data file which has been recorded from the start of recording to the abend can be restored when power is restored, whereby the reproducible area can be restored in a file format. Accordingly, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

According to an seventh aspect of the present invention, the digital data recording/reproduction apparatus of any of the eleventh through tenth aspects further comprises: a digital broadcast receiver for receiving a digital broadcast; and a controller for controlling the file structure management unit according to accounting information which indicates whether the received digital broadcast is a fee-charged broadcast or not. When an abend of data recording occurs during reception of a fee-charged digital broadcast, the controller discards the recorded data after recovery from the abend so that accounting is not performed on the digital broadcast.

Therefore, even when an abend such as a power failure occurs during data recording, the file until interruption due to the abend can be restored if the digital broadcast is free of charge. Further, when the digital broadcast whose recording is interrupted due to the abend is a fee-charge broadcast, no accounting is performed on this broadcast by discarding the data which has been

recorded until the interruption. In this way, appropriate accounting for the user is carried out.

According to a twelfth aspect of the present invention, a digital data recording/reproduction apparatus for recording and reproducing digital data comprises: a plurality of disk storage units in which digital data are recorded; and a file structure management unit for recording a cluster in which digital data is stored and a file allocation table for managing information corresponding to a connection of the cluster in different disk storage units.

Therefore, high-speed disk access is achieved, and even if an abend such as a power failure occurs during recording of digital data, the data which has been recorded from the start of recording to the abend can be read in a normal file format when power is restored. Accordingly, the destruction of a file and the loss of data, which are attendant on an abend, can be avoided inexpensively.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram illustrating the structure of a digital data recording/reproduction apparatus according to a first embodiment of the present invention.

Figure 2(a) is a diagram illustrating a file structure of a disk recording medium when no data is recorded in the disk

recording medium, according to the first embodiment of the present invention.

Figure 2(b) is a diagram illustrating the file structure of the disk recording medium when data is being recorded in the disk recording medium, according to the first embodiment of the present invention.

Figure 2(c) is a diagram illustrating the file structure of the disk recording medium when data recording is ended according to the first embodiment of the present invention.

Figure 3 is a flowchart illustrating a digital data recording/reproduction method according to the first embodiment of the invention.

Figure 4 is a block diagram illustrating the structure of a digital data recording/reproduction apparatus according to a second embodiment of the invention.

Figure 5 is a diagram illustrating the structure of a transport packet according to the second embodiment of the invention.

Figure 6 is a flowchart illustrating the file recovery process upon restoration of power according to the second embodiment of the invention.

Figure 7 is a diagram for explaining the data format of PES data according to a third embodiment of the invention.

Figure 8 is a flowchart illustrating the file recovery

process upon restoration of power according to the third embodiment of the invention.

Figure 9 is a diagram illustrating a file structure of a disk recording medium according to a fourth embodiment of the invention.

Figure 10 is a diagram illustrating the data structure of a cluster according to the fourth embodiment of the invention.

Figure 11(a) is a diagram illustrating the file structure when an abend such as a power failure occurs according to the fourth embodiment of the invention.

Figure 11(b) is a diagram illustrating the state of the cluster when an abend such as a power failure occurs according to the fourth embodiment of the invention.

Figure 12 is a flowchart illustrating the file recovery process upon restoration of power according to the fourth embodiment of the invention.

Figure 13(a) is a diagram illustrating the structure of a digital data recording/reproduction apparatus according to a fifth embodiment of the invention.

Figure 13(b) is a diagram illustrating fee-charged broadcast accounting information according to the fifth embodiment of the invention.

Figure 14 is a flowchart illustrating the process of controlling digital data recording/reproduction according to

the fifth embodiment of the invention.

Figure 15 is a block diagram illustrating the structure of a digital data recording/reproduction apparatus according to a sixth embodiment of the invention.

Figure 16 is a diagram illustrating the structure of the conventional UPS system.

Figure 17 is a diagram illustrating the conventional file structure.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

Hereinafter, a method and an apparatus for recording/reproducing digital data according to a first embodiment of the present invention will be described with reference to the drawings. In the digital data recording/reproduction method according to the first embodiment, a recordable area in which recordable clusters are connected is constructed on a disk recording medium in advance of recording, and digital data from a recording head cluster to a recording end cluster are constructed as a recorded file when recording is ended.

Figure 1 is a block diagram illustrating the structure of a digital data recording/reproduction apparatus 20 according to the first embodiment of the present invention.

The digital data recording/reproduction apparatus 20 comprises a data I/O unit 21, a file structure management unit 22, and a disk recording medium 23.

When receiving data, the data I/O unit 21 receives digital data from an externally-connected digital data input device (not shown), and outputs the digital data to the file structure management unit 22. When reproducing data, the data I/O unit 21 receives digital data from the file structure management unit 22, and outputs the digital data to an externally-connected digital data reproduction device (not shown).

The file structure management unit 22 manages the file structure of the disk recording medium 23, records the digital data in the disk recording medium 23 when data is received from the externally-connected digital data input device by the data I/O unit 21, and reads the digital data from the disk recording medium 23 when data is outputted to the externally-connected digital data reproduction device from the data I/O unit 21.

The disk recording medium 23 is a disk type recording medium in which digital data is stored therein.

Figures 2(a) to 2(c) are diagrams illustrating the file structure of the disk recording medium 23.

In figures 2(a) to 2(c), the file structure of the disk recording medium 23 is composed of a root directory 101, a file allocation table 102, and clusters 103.

The root directory 101 holds the head cluster number of the recordable area, the title of a data file that is recorded, and the head cluster number where the data of the data file is stored in the disk recording medium 23. The file allocation table 102 manages the connection of the clusters 103 in the data file by storing, in the position of the current cluster number, a cluster number which follows the current cluster number. Each of the clusters 103 is the smallest access unit of the disk recording medium 23, and continuous cluster numbers are assigned as logical block addresses to the respective clusters 103. The digital data of the data file is stored in the clusters 103.

Figure 2(a) shows the file structure when data is not yet recorded.

With reference to figure 2(a), in the root directory 101, no recorded data file exists, and "Free Area" indicates that a recordable area exists. The Free Area starts from the cluster number 0002. In the file allocation table 102, FFFF means that no cluster follows the current cluster, i.e., FFFF means the final cluster.

In the file structure when data is not yet recorded, the file allocation table 102 is constituted such that the Free Area is constituted by all clusters being connected successively starting from the cluster number 0002.

Next, the data recording operation will be described with

reference to figures 1, 2(a)-2(c), and 3.

Figure 3 is a flowchart illustrating the digital data recording/reproduction method.

Initially, when the disk recording medium 23 is formatted or before recording is started, the file structure management unit 22 constructs the recording area of the disk recording medium 23 such that the recording area has a file structure in which all of the cluster numbers are continuous as shown in figure 2(a) (step S31). After constructing the file structure, data recording is started.

Digital data is supplied from an externally-connected digital data input device (not shown) to the data I/O unit 21. The data I/O unit 21 outputs the digital data to the file structure management unit 22.

Figure 2(b) shows the file structure when data recording is started.

In figure 2(b), when data recording is started, the file structure management unit 22 copies the head cluster number (in this case, 0002) that is assigned to the Free Area of the root directory 101 into the head cluster number storage area of a data file "Video", and stores FFFF, which indicates that there is no cluster 103 assigned, into the head cluster number storage area of the Free Area indicating the recordable area.

Since the root directory 101 is altered, the construction

of the file allocation table 102 is altered such that the data file Video shows the area where all of the clusters are connected successively starting from the cluster number 0002.

When recording data, digital data, such as video data, is recorded from the head of the cluster 103, which is assigned to the data file Video, when recording is started (step S32).

Figure 2(c) shows the file structure when data recording is ended.

With reference to figure 2(c), when data recording is ended, the file structure management unit 22 stores FFFF, which indicates the final cluster of the data file, in a position of the file allocation table 102 corresponding to the most-recently recorded cluster 103.

Then, in the root directory 101, a cluster number following the most-recently recorded cluster 103 (in this case, 2000) is stored in the head cluster number storage area of the data in the Free Area indicating the recordable area.

Thereby, an area starting from the head cluster that is assigned to the Free Area indicating the recordable area is used when the next data file is recorded. In this way, the digital data from the recording head cluster to the recording end cluster are constituted as a recorded file (step S33).

If an abend such as a power failure occurs during data

recording in the above-described file structure (e.g., if an abend occurs when the cluster number 1FFF is being written), the file structure is in the state of figure 2(b), and the data file is in the state where the already recorded clusters from the cluster number 0002 to the cluster number 1FFF are connected to the unrecorded clusters 2000 and onward.

As described above, the method and apparatus for recording/reproducing digital data according to the first embodiment use the disk recording medium 23 having the file structure in which all of the clusters in the recordable area are connected in advance. Further, as also described above, the method and the apparatus for recording/reproducing digital data according to the first embodiment include the file structure management 22 which stores, when recording is ended, an identifier which indicates the final cluster in the cluster where data has been recorded most recently, and the cluster number following the most-recently recorded cluster in the head cluster of the recordable area. Therefore, even when an abend such as a power failure occurs during recording of digital data, the area where the digital data has been recorded exists as a part of the file when power is restored, whereby the data which has been recorded from the start of recording to the abend can be reproduced after the apparatus is recovered from the abend.

While FFFF is used as an identifier indicating that no

recordable area exists in the first embodiment, any other value may be used so long as such value is not used as a cluster number.

Second Embodiment

Hereinafter, a method and an apparatus for recording/reproducing digital data according to a second embodiment of the present invention will be described with reference to the drawings.

In the digital data recording/reproduction method according to the second embodiment, the procedure according to the first embodiment further includes a step of checking whether there is any dropout of a synchronous byte in the cluster data to obtain the head cluster number of the interrupted file.

The file structure of the disk recording medium 23 according to the second embodiment is identical to that of the first embodiment shown in figures 2(a) to 2(c). In the second embodiment, FFFF, which is stored in the head cluster number storage area of the Free Area indicating the recordable area in figure 2(b), indicates that data recording can be continued.

Figure 4 is a block diagram illustrating the structure of a digital data recording/reproduction apparatus 24 according to the second embodiment.

The digital data recording/reproduction apparatus 24 comprises a data I/O unit 21, a file structure management unit 25,

and a disk recording medium 23. The file structure management unit 25 further includes a file recovery unit 26. The constituents and operations other than the file structure management unit 25 and the file recovery unit 26 are identical to those already described for the first embodiment and, therefore, do not require repeated description.

The file structure management unit 25 manages the file structure of the disk recording medium 23, records digital data in the disk recording medium 23 when receiving the data, and reads the digital data from the disk recording medium 23 when outputting the data.

In the case where an abend such as a power failure occurs during recording of digital data, the file recovery unit 26 performs recovery, upon restoration of power, such that the data which have been recorded from the start of recording to the abend are constituted as one recorded file like in the case where recording is normally ended.

Figure 5 is a diagram illustrating the structure of a transport packet which is a data format of digital broadcasting.

In figure 5, the transport packet is composed of a transport header 201 as header information, and a payload 202 as actual data of the digital data. The transport packet has a fixed length. A sync byte 203 used for synchronization exists at the beginning of the transport header 201. A digital broadcast is constituted

by a repetition of this transport packet.

Next, a description will be given of the file recovery process upon restoration of power in the case where an abend such as a power failure occurs during recording of data in the disk recording medium 23 having the file structure shown in figures 2 (a) to 2 (c) .

Figure 6 is a flowchart illustrating the file recovery process upon restoration of power. This process is performed by the file recovery unit 26 unless otherwise specified.

Initially, in step S301, it is decided whether data recording is interrupted or not by checking the root directory 101 of figure 2(b) as to whether the head cluster number assigned to the Free Area indicating the recordable area is FFFF, which indicates that recording is continued. When recording is not interrupted, i.e., when the head cluster number assigned to the Free Area is not FFFF, the power restoration process is ended. When recording is interrupted, i.e., when the head cluster number assigned to the Free Area is FFFF, the file recovery process proceeds to step S302 to continue the power restoration process.

In step S302, the head cluster number of the recording-interrupted file, whose connection on the file allocation table 102 is not concluded by the final cluster (in this case, FFFF), is obtained as a current cluster from the root directory 101.

In step S303, it is checked whether there is a dropout of a

sync byte 203 in the current cluster. When there is a dropout of a sync byte 203, it is decided that recording is interrupted in the current cluster, and the file recovery process proceeds to step S304. When there is no dropout of a sync byte 203, it is decided that recording is not interrupted in the current cluster, and the file recovery process proceeds to step S307.

In step S304, FFFF, which indicates the final cluster, is stored in the position of the cluster number corresponding to the current cluster on the file allocation table 102.

In step S305, the cluster number following the current cluster is obtained as a head free cluster from the file allocation table 102.

In step S306, the head free cluster is stored in the head cluster number storage area of the Free Area in the root directory 101. Then, the power restoration process is ended.

In step S307, it is checked whether there is a cluster following the current cluster. When there is a cluster following the current cluster, the file recovery process proceeds to step S308. On the other hand, when there is no cluster following the current cluster, it is decided that recording has been performed up to the final cluster, and the power restoration process is ended.

In step S308, the cluster number following the current cluster is obtained from the file allocation table 102, and the

current cluster is replaced with this cluster number so as to update the current cluster. Then, the file recovery unit 26 returns to step S303 to repeat the process of checking the sync byte 203.

Next, the file recovery process upon restoration of power will be described by using an example.

It is assumed that a power failure occurs during recording of data in the cluster 103 having the cluster number 1FFF. In this case, when the file recovery unit 26 checks whether there is a dropout of a sync byte 203, starting from the head cluster number of the recording-interrupted file, the file recovery unit 26 becomes incapable of detecting the sync byte 203 at the cluster number 1FFF (step S303). So, FFFF, which indicates the final cluster of the data file, is stored in the position of the cluster number 1FFF on the file allocation table 102 (step S304). In the root directory 101, the cluster number 2000, which follows the cluster number 1FFF that has been recorded most recently, is stored in the head cluster number storage area of the Free Area indicating the recordable area instead of FFFF indicating that recording is to be continued (step S306). Thereby, the recording-interrupted file is restored to the file structure shown in figure 2(c) as in the case where recording is normally ended.

As described above, in the method and apparatus for recording/reproducing digital data according to the second

embodiment, recording of digital data is performed using the disk recording medium 23 having the file structure in which all of the clusters in the recordable area are connected in advance. Therefore, even when an abend such as a power failure occurs during recording of digital data, the data which has been recorded from the start of recording to the abend can be reproduced when power is restored. Further, by making good use of the Free Area as the recordable area, the recordable area can be restored to the same file format as that of a file for which the data-recording end process is normally performed.

While a transport packet is described as a digital data format for recording in the second embodiment, the same processing as described above can be performed on pack data by utilizing a pack start code as a sync byte.

Further, while the head cluster number of the interrupted file is obtained by checking whether there is a dropout of sync byte in the second embodiment, the head cluster number may be obtained on the basis of other format information of digital data.

Third Embodiment

Hereinafter, a method and an apparatus for recording/reproducing digital data according to a third embodiment of the present invention will be described with reference to the drawings. In the digital data

recording/reproduction method according to the third embodiment, the step of checking whether there is a dropout of a sync byte in the cluster according to the second embodiment is replaced with a step of checking whether there is a dropout of a marker bit or a decrease in a PTS in the cluster.

The file structure of the disk recording medium and the digital data recording/reproduction apparatus according to the third embodiment are shown in figures 2(a)-2(c) and figure 4, respectively. That is, the file structure and the apparatus are identical to those of the second embodiment, and therefore, repeated description is not necessary. In this third embodiment, FFFF, which is stored in the head cluster number storage area of the Free Area (the recordable area) shown in figure 2(b), indicates that data recording is continued. Further, in this third embodiment, the file recovery unit 26 shown in figure 4 performs file recovery when the file recovery unit 26 detects a dropout of a marker bit or a decrease in a PTS.

Figure 7 is a diagram for explaining a data format of PES data which is obtained by collecting payload sections of transport packets shown in figure 5.

The PES data is composed of a packet header 401 as an information area of PES, and packet data 402 as actual data. The packet header 401 includes a PTS 403 as time control information for reproduced output data, and the PTS 403 increments in value

according to the data. The PTS 403 includes marker bits (M)404 which always take on "1".

Next, a description will be given of the file recovery process upon restoration of power in the case where an abend such as a power failure occurs during data recording.

Figure 8 is a flowchart illustrating the file recovery process upon restoration of power. In figure 8, steps S501, S502 and S503 to S508 are identical to steps S301, S302 and S303 to S308 of the flowchart of the second embodiment shown in figure 6, respectively, and therefore repeated description is not necessary. Further, the file recovery process is performed by the file recovery unit 26 unless otherwise specified.

In step S503, it is checked whether there is a dropout of a marker bit 404 or a decrease in a PTS 403 in the current cluster. When there is a dropout of marker bit 404 or a decrease in a PTS 403, it is decided that recording is interrupted in the current cluster, and the file recovery process proceeds to step S504. When there is neither a dropout of a marker bit 404 nor a decrease in a PTS 403, it is decided that recording is not interrupted in the current cluster, and the file recovery process proceeds to step S507.

Next, the file recovery process upon restoration of power will be described by using an example.

It is assumed that a power failure occurs during recording

of data in the cluster 103 having the cluster number 1FFF. In this case, when the file recovery unit 26 checks whether the PTS 403 is normal or not (i.e., whether there is a decrease in the PTS 403), starting from the head cluster number of the recording-interrupted file, the file recovery unit 26 detects that the PTS 403 is not normal at the cluster number 1FFF (step S503). So, FFFF, which indicates the final cluster of the data file, is stored in the position of the cluster number 1FFF on the file allocation table 102 (step S504). In the root directory 101, the cluster number 2000 following the cluster number 1FFF, which has been recorded most recently, is stored in the head cluster number storage area of the Free Area indicating the recordable area instead of FFFF indicating that recording is continued (step S506). Thereby, the recording-interrupted file is restored to the file structure shown in figure 2(c) as in the case where recording is normally ended.

As described above, in the method and apparatus for recording/reproducing digital data according to the third embodiment, recording of digital data is performed using the disk recording medium having the file structure in which all of the clusters in the recordable area are connected in advance. Therefore, even when an abend such as a power failure occurs during recording of digital data, the data which has been recorded from the start of recording to the abend can be reproduced when power

is restored. Moreover, by making good use of the Free Area as the recordable area, the recordable area can be restored to the same file format as that of a file for which the data-recording end process is normally performed.

While a transport packet is described as a digital data format for recording in the third embodiment, the same processing as described above can be performed on pack data by utilizing a pack start code as a sync byte.

Further, while FFFF is employed as an identifier indicating that recording is continued in the second and third embodiments, any other value may be used as long as such value is not used as a cluster number.

Fourth Embodiment

Hereinafter, a method and an apparatus for recording/reproducing digital data according to a fourth embodiment of the present invention will be described with reference to the drawings. In the digital data recording/reproduction method according to the fourth embodiment, each cluster is provided with an area where a file ID for identifying a data file is stored, and file recovery is performed according to the file ID.

The digital data recording/reproduction apparatus according to the fourth embodiment is identical to the digital data recording/reproduction apparatus according to the second

embodiment shown in figure 4.

Figure 9 is a diagram illustrating the file structure of a disk recording medium 23 according to the fourth embodiment.

In figure 9, the recording area of the disk recording medium 23 is composed of a root directory 601, a file allocation table 602, and clusters 603. The root directory 601 holds the title of a file stored in the disk recording medium 23, and the root directory 601 holds the head cluster number where data of this file is stored. The file allocation table 602 manages the connection of the clusters 603 by storing, in the position of the current cluster number, a cluster number which follows the current cluster number. Each cluster 603 is the smallest access unit of the disk recording medium 23, and continuous numbers are assigned as logical block addresses to the respective clusters 603. The digital data of the data file is stored in the clusters 603.

When recording data, the file name and the head cluster number are entered in the root directory 601, and the data is recorded in each cluster 603 while updating the connection information of the clusters 603 on the file allocation table 602. In order to achieve high-speed disk access, writing of data in the clusters 603 is executed while updating the connection information of the clusters 603 in a memory (not shown) that is possessed by the file structure management unit 25, and, when the data writing is ended, i.e., when the file is closed, the cluster connection information

stored in the memory is written in the file allocation table 602 of the disk recording medium 23.

Next, the data structure of the cluster 603 will be described with reference to figure 10.

Figure 10 is a diagram illustrating the data structure of the cluster 603.

In figure 10, one cluster 603 is composed of recording information 701 where information at the recording of digital data is stored, and digital data 702 as actual data. The recording information 701 is composed of a file ID 703 for identifying a data file, and a connecting cluster number 704 where a cluster number following this cluster is stored i.e., the cluster number of a sequential cluster. This fourth embodiment employs, as the file ID 703, the recording start time (year, month, hour, minute, second) which is represented by ASCII code.

Figure 11(a) shows the state of the file structure of the disk recording medium 23 in the case where an abend such as a power failure occurs when a data file Videol is being recorded in the cluster 603 of the cluster number 0004, i.e., before the file allocation table 602 is updated.

In figure 11(a), although the root directory 801 and the cluster 803 are in their normal states, the file allocation table 802 lacks cluster connection information.

Figure 11(b) shows the state of the cluster 803 in the

case where recording is interrupted.

In figure 11(b), the same recording start time is stored in the file IDs 804 of the clusters in which the digital data 806 of the data file Videol is written, and the cluster connection information is stored in the connecting cluster numbers 805. The reason why the connecting cluster number 805 of cluster 4 is "undefined" is because an abnormal cluster number, e.g., cluster number 1000, is stored in the connecting cluster number 805.

Next, the file recovery process upon restoration of power will be described with reference to figure 12.

Figure 12 is a flowchart illustrating the file recovery process upon restoration of power. This process is performed by the file recovery unit 26 unless otherwise specified.

Initially, in step S901, it is decided whether recording is interrupted or not by checking the cluster connection information on the file allocation table 802 starting from the head cluster number of the data file Videol in the root directory 801 shown in figure 11(a). When recording is not interrupted, i.e., when the cluster connection on the file allocation table 802 is in the normal state, the power restoration process is ended. On the other hand, when recording is interrupted, the file recovery process proceeds to step S902.

In step S902, the head cluster number of the recording-

interrupted file is obtained as a current cluster from the root directory 801, and the file ID804 of the head cluster is regarded as a target file ID.

In step S903, the connecting cluster number 805 of the current cluster 803 is obtained as a next cluster.

In step S904, when the file ID 804 of the next cluster is different from the target file ID, it is decided that recording is interrupted in the current cluster, and the file recovery process proceeds to step S905. On the other hand, when the file ID804 of the next cluster is identical to the target file ID, it is decided that data recording is not interrupted in the current cluster, and the file recovery process proceeds to step S906.

In step S905, FFFF, which indicates the final cluster, is stored in the position of the cluster number corresponding to the current cluster on the file allocation table 802. Then, the power restoration process is ended.

In step S906, the number of the next cluster is stored in the position of the current cluster on the file allocation table 802 so as to restore the cluster connection, and the current cluster is updated to the value of the next cluster, whereupon the file recovery process proceeds to step S903. Thereafter, the check of the file ID 804 (steps S903 and S904) is repeated.

Next, the file recovery process upon restoration of power will be described by using an example.

It is assumed that a power failure occurs during recording of data in the cluster 803 having the cluster number 0004. In this case, when the file recovery unit 26 checks whether the current cluster and the next cluster have the same file ID, starting from the head cluster 0002 of the data file Videol, the file recovery unit 26 detects that the current cluster and the next cluster have different file IDs when the current cluster has the cluster number 0004 (step S904). So, FFFF, which indicates the final cluster of the data file, is stored in the position of the cluster number 0004 on the file allocation table 802 (step S905). Thereby, the data file Videol is restored to a recorded file shown in figure 9 as in the case where recording is normally ended.

As described above, in the method and apparatus for recording/reproducing digital data according to the fourth embodiment, since the file ID for identifying the data file and the connecting cluster number indicating the cluster connection are stored in each cluster, even when an abend occurs during recording of digital data, the file allocation table 602 of the data file which has been recorded from the start of recording to the abend can be restored when power is restored, whereby the reproducible part can be restored in a file format.

While the recording start time (year, month, hour, minute, second) is used as a file ID in the fourth embodiment, a counter

having no repeatability may be used.

Further, while in 0000 is used as a value indicating that the file allocation table 802 has no cluster connection information in the fourth embodiment, any other value may be used as long as such value is not used as a cluster number.

Further, while the recordable area is described as all of the clusters in the first through fourth embodiments, the recordable area may be assigned to some of the clusters while using the remaining clusters as a recording area for computer data.

Further, while FFFF is used as an identifier indicating that the current cluster is the final cluster followed by no other cluster in the first through fourth embodiments, any other value may be used as long as such value is not used as a cluster number.

Fifth Embodiment

Hereinafter, a digital data recording/reproduction apparatus according to a fifth embodiment of the present invention will be described with reference to the drawings.

The digital data recording/reproduction apparatus according to the fifth embodiment can deal with an abend such as a power failure which occurs during recording of a fee-charged broadcast, by using the digital data recording/reproduction method according to any of the second to

fourth embodiments.

Figure 13(a) is a diagram illustrating the structure of the digital data recording/reproduction apparatus according to the fifth embodiment.

With reference to figure 13(a), the digital data recording/reproduction apparatus comprises a digital broadcast receiver 1001, a decoder 1002, a digital data recording/reproduction controller 1003, a disk storage unit 1005, and a data destination switch 1006. The digital data recording/reproduction controller 1003 comprises a data I/0 unit 21, a file structure management unit 25, and a controller 27. Further, the file structure management unit 25 is provided with a file recovery unit 26. The data I/0 unit 21, the file structure management unit 25, and the file recovery unit 26 operate in the same way as described for any one of the second to fourth embodiments of the present invention, and therefore, repeated description is not necessary.

The digital broadcast receiver 1001 receives a digital broadcast 10A, extracts copy protection information from the digital broadcast 10A, and performs demultiplexing to extract a program that is designated by the user. Further, the digital broadcast receiver 1001 performs descrambling on the basis of the copy protection information if necessary, and extracts digital data 10B of the program that is extracted from the digital

broadcast 10A. The digital data 10B of the program that is extracted by the digital broadcast receiver 1001 is output to the digital data recording/reproduction controller 1003.

The decoder 1002 receives the digital data 10B from the digital data recording/reproduction controller 1003, decodes the digital data 10B to convert the digital data 10B to analog data, and outputs video and audio.

The controller 27 of the digital recording/reproduction controller 1003 records accounting information 10D in a master card 1004. When the data destination switch 1006 designates only reproduction or both of reproduction and recording, the controller 27 instructs the file structure management unit 25 to output the digital data 10B to the decoder 1002 by way of the data I/O unit 21. When the data destination switch 1006 designates only recording or both of reproduction and recording, the controller 27 instructs the file structure management unit 25 to record the digital data 10B in the disk storage unit 1005 by a digital data recording/ reproduction method according to any one of the second to fourth embodiments.

When the file recovery unit 26 detects that data recording is abnormally ended due to a power failure or the like after power-ON, the controller 27 instructs the file structure management unit 25 to delete the file which has been recorded in the disk storage unit 1005 until the abend, and the controller 27 deletes the program

from the fee-charged broadcast accounting information 10D.

The accounting information 10D is recorded in the master card 1004.

In the disk storage unit 1005, the digital data 10B is recorded in a file format according to any one of the second to fourth embodiments.

When the user designates, as the destination of the received data, a single application mode of only reproduction, only recording, or both of reproduction and recording, the data destination switch 1006 outputs a signal 10C designating the application mode to the digital data recording/reproduction controller 1003.

Figure 13(b) is a diagram for explaining the format of accounting information that is recorded in the master card 1004.

In figure 13(b), the accounting information format is composed of a charge-for-broadcast 1007 indicating the charge per view, a view mode 1008 for identifying whether the broadcast is reproduced or recorded when being viewed, and a program file 1009 indicating the name of a file when the received broadcast is recorded in the disk storage unit 1005.

Next, the operation of the digital data recording/ reproduction apparatus according to the fifth embodiment will be described.

First of all, a description will be given of the case where the received digital broadcast 10A is reproduced or recorded.

Before receiving the broadcast, the user of the digital data recording/reproduction apparatus selects a data output mode (application mode), i.e., one of "both of reproduction and recording", "only reproduction", and "only recording", and sets the application mode in the data destination switch 1006.

The digital broadcast that is transmitted from the broadcast station is input to the digital broadcast receiver 1001. The digital broadcast receiver 1001 takes (extracts) the copy protection information out of the digital broadcast, and performs demultiplexing so as to extract the program from the digital broadcasti that is designated by the user. Further, the digital broadcast receiver 1001 performs descrambling on the basis of the copy protection information if required, extracts the digital data 10B of the user-designated program, and outputs the digital data 10B of the program to the digital data recording/reproduction controller 1003.

The digital data recording/reproduction controller 1003 records the accounting information 10D in the master card 1004. When the designation of the data destination switch 1006 includes reproduction, the digital data recording/reproduction controller 1003 outputs the digital data 10B to the decoder 1002. When the designation of the data destination switch 1006

includes recording, the digital data recording/reproduction controller 1003 stores the digital data 10B in the disk storage unit 1005.

When the digital data 10B is output to the decoder 1002, the decoder 1002 decodes the digital data 10B so as to convert the digital data 10B to analog data, and the decoder 1002 outputs video and audio.

Recording of the digital data 10B in the disk storage unit 1005 is performed by using a digital data recording/reproduction method according to any of the first to fourth embodiments.

Next, a description will be given of the operation for reproducing the digital data 10B that is recorded in the disk storage unit 1005.

When reproducing the digital data 10B from the disk storage unit 1005, the digital data recording/reproduction controller 1003 reads the digital data 10B from the disk storage unit 1005, and transmits the digital data 10B to the decoder 1002, whereby analog data is reproduced.

Next, with reference to figure 14, a description will be given of the operation of the digital data recording/reproduction controller 1003 in the case where an abend such as a power failure occurs during recording of a fee-charged broadcast program.

Figure 14 is a flowchart illustrating the process performed by the digital data recording/reproduction controller 1003 in the case where an abend such as a power failure occurs during recording of a fee-charged broadcast program.

Initially, in step S111, the file recovery unit 26 checks whether data recording is abnormally ended or not by a digital data recording/reproduction method according to any one of the second to fourth embodiments. When recording is not interrupted, the power restoration process is ended. When, recording is interrupted, the operation proceeds to step S112.

In step S112, the file structure management unit 25 obtains the name of the data file which has been recorded in the disk storage unit 1005 until the abend, and the file structure management unit 25 regards this file as an interrupted file.

In step S113, the controller 27 checks whether the interrupted file matches any of the program files 1009 in the fee-charged broadcast accounting information. When there is no program file which matches the interrupted file, the controller 27 decides that a free-of-charge broadcast has been recorded, and the operation proceeds to step S114. On the other hand, when there is a program file matching the interrupted file, the operation proceeds to step S115.
In step S114, the file recovery unit 26 restores the recording-

interrupted file by using a digital data recording/reproduction method according to any one of the second to fourth embodiments. Then, the power restoration process is ended.

In step S115, the controller 27 checks the view mode 1008 that is stored in the master card 1004. When the view mode 1008 is "only recording", the operation proceeds to step S116. In step S116, the controller 27 instructs the file structure management unit 25 to delete the interrupted file from the disk storage unit 1005. Then, the file structure management unit 25 deletes the interrupted file from the disk storage unit 1005. Thereafter, the operation proceeds to step S117-wherein the controller 27 deletes the corresponding program from the fee-charged broadcast accounting information so as to end the power restoration process.

When the view mode 1008 is "both of recording and reproduction", the controller 27, in step S118, instructs the file structure management unit 25 to delete the interrupted file from the disk storage unit 1005. Then, the file structure management unit 25 deletes the interrupted file from the disk storage unit 1005. Thereafter, the operation proceeds to step S119 wherein the charge for recording is subtracted from the charge-for-broadcast 1007. Then, the power restoration process is ended.

As described above, in the digital data recording/

reproduction apparatus according to this fifth embodiment, a digital broadcast is recorded by using a file structure according to any one of the second to fourth embodiments. Therefore, even when an abend such as a power failure occurs during data recording, the file until interruption due to the abend can be restored if the digital broadcast is free of charge. Further, even when recording of a fee-charged broadcast is interrupted due to an abend, no accounting is performed on this broadcast by discarding the data which has been recorded until the interruption. Thus, proper accounting for the user is performed.

While the recorded data is unconditionally discarded when an abend occurs during recording of a fee-charge broadcast program in the fifth embodiment, the user may decide whether the data which has been recorded until the abend is to be saved or discarded.

Sixth Embodiment

Hereinafter, a digital data recording/reproduction apparatus according to a sixth embodiment of the present invention will be described with reference to the drawings.

The digital recording/reproduction apparatus according to the sixth embodiment is provided with a plurality of disk storage units. A cluster where digital data is stored and a file allocation table showing information about connection of the cluster are recorded in each of the plurality of disk storage units, whereby

the load is reduced as compared with the case of using a single disk storage unit, which results in high-speed disk access.

Figure 15 is a diagram illustrating the structure of the digital data recording/reproduction apparatus according to the sixth embodiment.

The digital data recording/reproduction apparatus of the sixth embodiment is provided with a data I/O unit 1201, a file structure management unit 1202, a disk storage unit A 1203, and a disk storage unit B 1204.

When receiving digital data, the data I/O unit 1202 receives digital data from a digital data input device which is externally connected, and the data I/O unit 1202 outputs the received digital data to the file structure management unit 1202. When reproducing the digital data, the data I/O unit 1201 receives the digital data from the file structure management unit 1202, and the I/O unit outputs the digital data to a digital data reproduction device which is externally connected.

Upon receipt of the digital data, the file structure management unit 1202 records the digital data in the disk storage unit A 1203 and the disk storage unit B 1204. When outputting the digital data, the file structure management unit 1202 reads the digital data from the disk storage unit A 1203 and the disk storage unit B 1204.

The digital data is recorded in the disk storage unit A 1203

and the disk storage unit B 1204. The file structure employed in the disk storage unit A 1203 and the disk storage unit B 1204 is identical to the file structure according to the fourth embodiment of the present invention shown in figure 9.

Next, a description will be given of the operation of recording digital data in the disk storage unit A 1203 and the disk storage unit B 1204.

When recording digital data, the file name and the head cluster number are entered in the root directory 601, and digital data is recorded in the respective clusters 603 while updating the cluster connection information on the file allocation table 602.

With reference to figure 15, the root directory 601 and the file allocation table 602 corresponding to the cluster B in the disk storage unit B 1204 are stored in the storage area for the root directory 601 and the file allocation table 602 in the disk storage unit A 1203, which is different from the disk storage unit B 1204, where the cluster B is stored. The root directory 601 and the file allocation table 602 corresponding to the cluster A in the disk storage unit A 1203 are stored in the storage area for the root directory 601 and the file allocation table 602 in the disk storage unit B 1204 which is different from the disk storage unit A 1203 where the cluster A is stored.

As described above, according to the digital data recording/reproduction method of this sixth embodiment, since a cluster containing digital data and a file allocation table showing information about connection of this cluster are recorded in different disk storage units, high-speed disk access is achieved. Further, even when an abend such as a power failure occurs during recording of digital data, the data which has been recorded from the start of recording to the abend can be read in a normal file format when power is restored.

While the root directory is stored in a disk storage unit which is different from the disk storage unit where the corresponding cluster is stored in the sixth embodiment, the root directory and the cluster may be stored in the same disk storage unit as long as the cluster and the file allocation table are stored in different disk storage units.

Further, while two disk storage units are used in the sixth embodiment, three or more disk storage units may be used as long as the cluster and the file allocation table are stored in difference disk storage units.

Furthermore, the file structure of the disk storage unit A 1203 and the disk storage unit B 1204 may be the conventional file structure as shown in figure 17.

While the data I/O unit 21 or 1201 performs both of data input and data output in the first through sixth embodiments, the data

I/O unit 21 may be separated into a data input unit and a data output unit.

Further, in the digital data recording/reproduction apparatuses according to the first to sixth embodiments, the file structure management units 22 and 25, the file recovery unit 26, and the controller 27 are implemented by either hardware or software.

Furthermore, "digital data" described in the first through sixth embodiments means either or both of video data and audio data.

Moreover, in the first to fourth and sixth embodiments, analog data may be encoded to digital data in advance of recording so as to record the analog data as digital data by a digital data recording/reproduction method.

As described above, the method and apparatus for recording/reproducing digital data according to the present invention perform recording or reproduction of video data, or audio data, or both of audio and video data, and are suited to data recording in the case where an abend such as a power failure occurs during data recording.